

Assistive Technology: Automated Calibration of Kinect-Based Keyboard Engineered for a Wounded Warrior

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Introduction

During his 5th combat deployment to Afghanistan, Captain A was severely injured when his vehicle was hit by an improvised explosive device (IED). He suffered two strokes, two heart attacks, an anoxic brain injury, and cardiac arrest, resulting in severe impairment to his speech, vision, and dexterity. These limitations increased the difficulty of performing everyday tasks and made it difficult for him to effectively use a standard computer keyboard. To help him with this problem, we designed and implemented a custom keyboard system to increase his accuracy and efficiency in using a computer.

Background

Previous implementation of the system employed a regular color-vision camera mounted directly above the keyboard facing downwards. The camera tracked the movement of and continually gave audio feedback on the location of stickers adhered to Captain A’s middle finger over the keyboard. Shortcomings of this implementation included inconvenience of the stickers and low reliability in various lighting conditions. To address these issues, the regular camera was replaced with the Microsoft Kinect 2.0, which has depth and infrared sensors in addition to the color camera to help address these issues.

General Methodology

- Color, depth, and infrared sensors used on three levels of detection using the Kinect-compatible language C# for custom programs
 - Hand detection
 - Finger detection
 - Keyboard detection

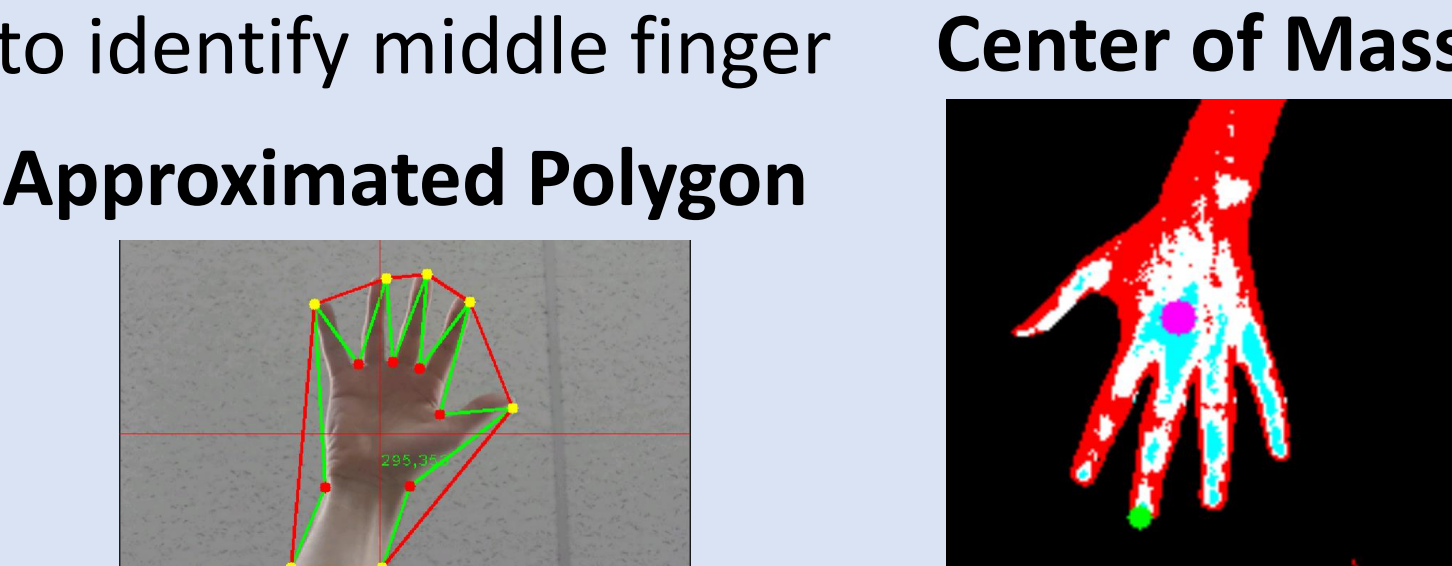
Hand Detection

- Depth image used to threshold the infrared image to remove unnecessary objects and noise, and to isolate the hand
- Edge detection used to outline objects and identify the hand by greatest area



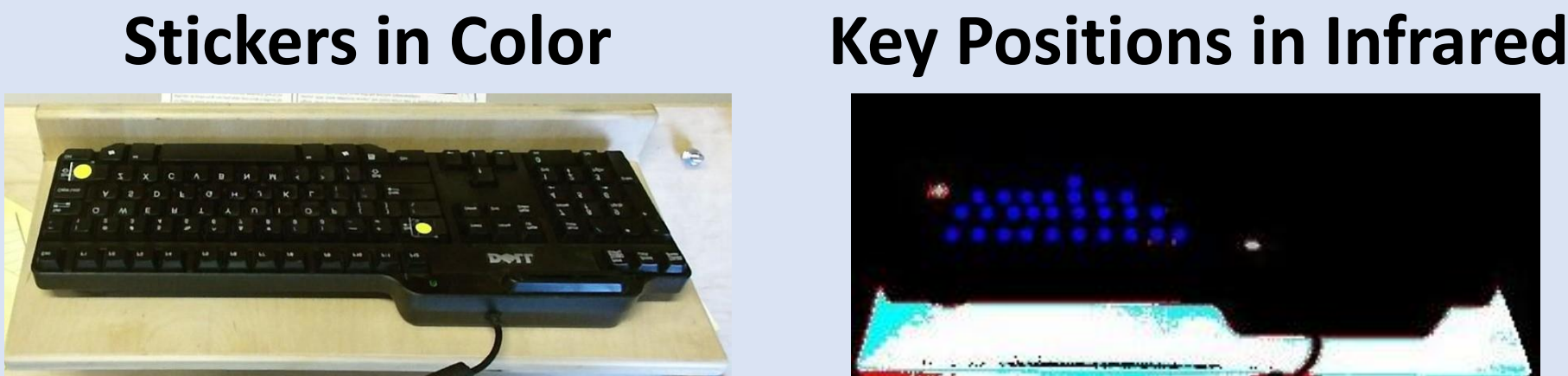
Finger Detection

- Infrared image used to approximate the entire hand as a polygon with the vertices as the fingertips
- Vertex farthest away from the center of mass of the hand used to identify middle finger



Keyboard Detection

- Currently tracks the location of the keyboard using stickers placed on the corners of the keyboard
- Locations of the individual keys extrapolated from sticker locations
- Text-to-speech software audibly announces the key when the tracked middle finger is detected to be within 3 pixels of a key location

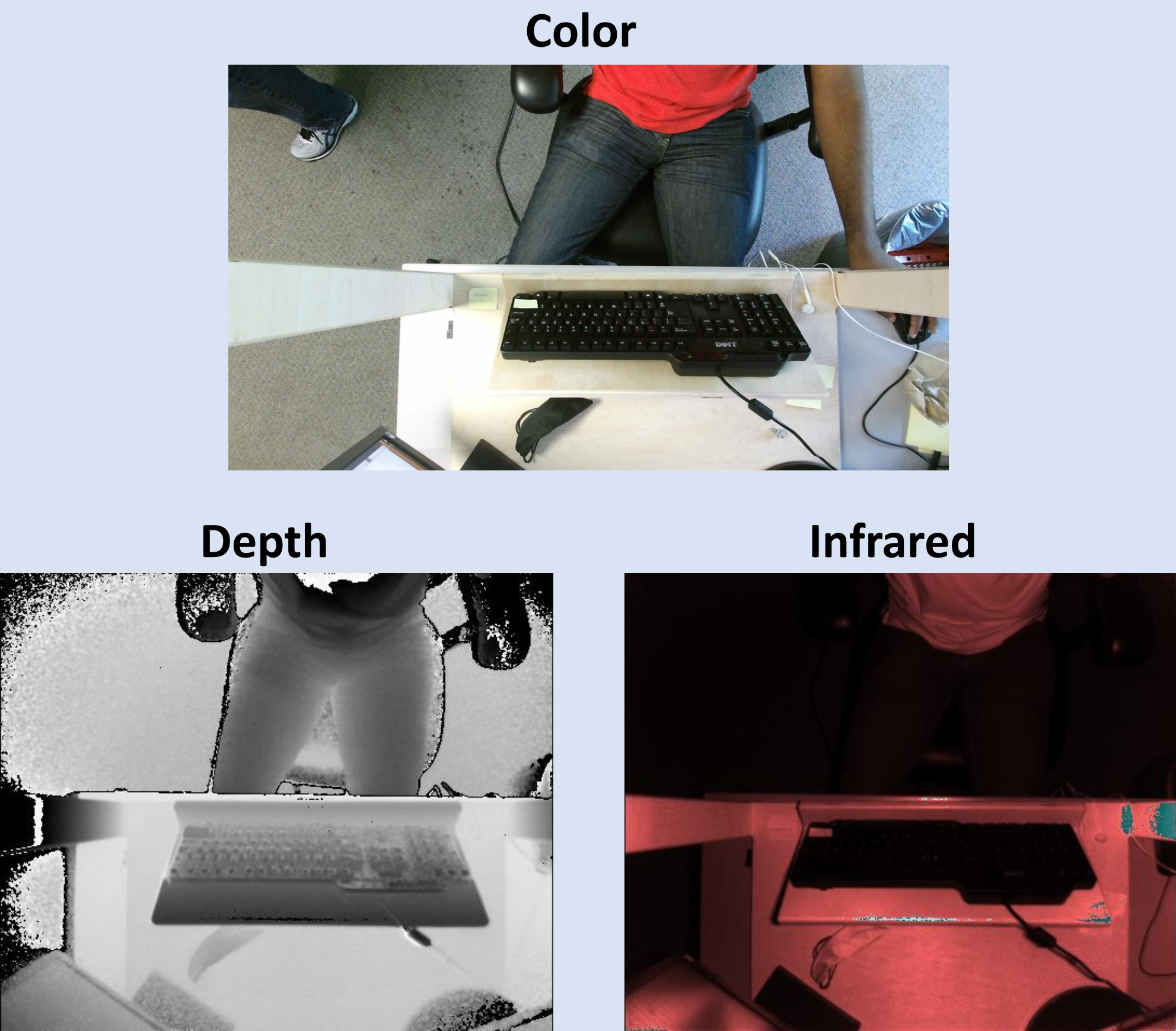


Goals

- Accurate identification of the keyboard and keys regardless of slight adjustments to the position of the keyboard relative to the Kinect camera
- Eliminate need to rely on stickers that interfere with the hand and finger detection in the infrared image
- Reduce quantity of keyboard alterations needed for compatibility
- Increase general utility of the system

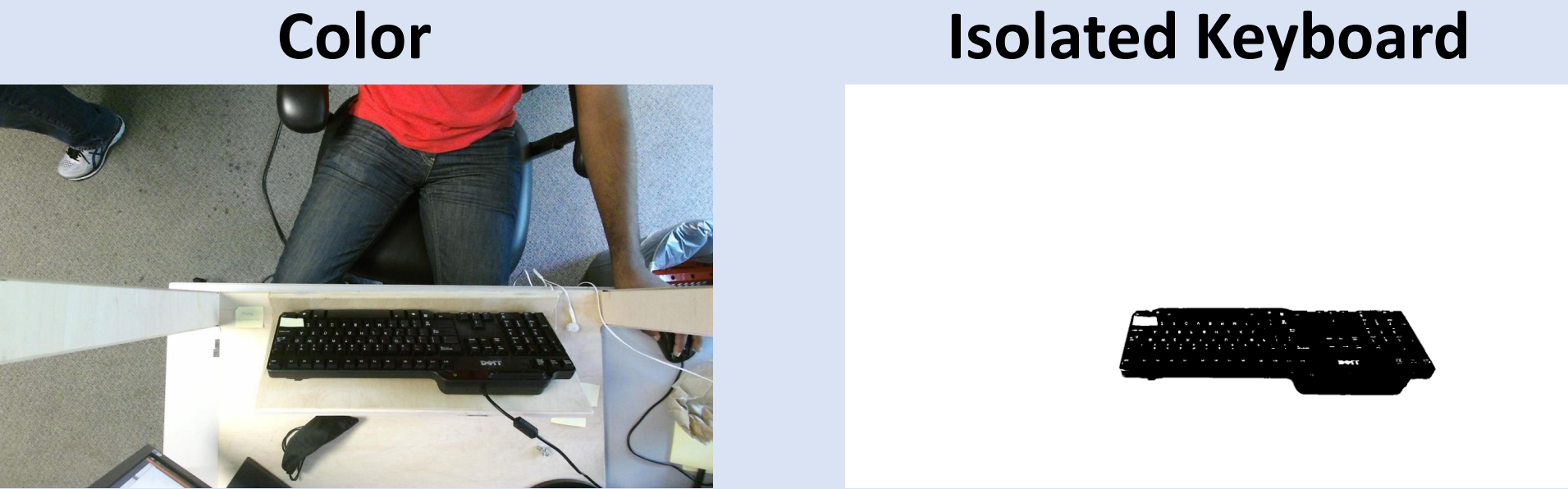
Automated Calibration Methodology

- Image processing of the color and infrared images using MATLAB
 - Isolation of keyboard in color image
 - Calibration of isolated keyboard with key positions
 - Registration of infrared image to color image
- Depth image not used
- Color image contains most useful information
- Infrared image used to identify the finger and keyboard in relation to one another



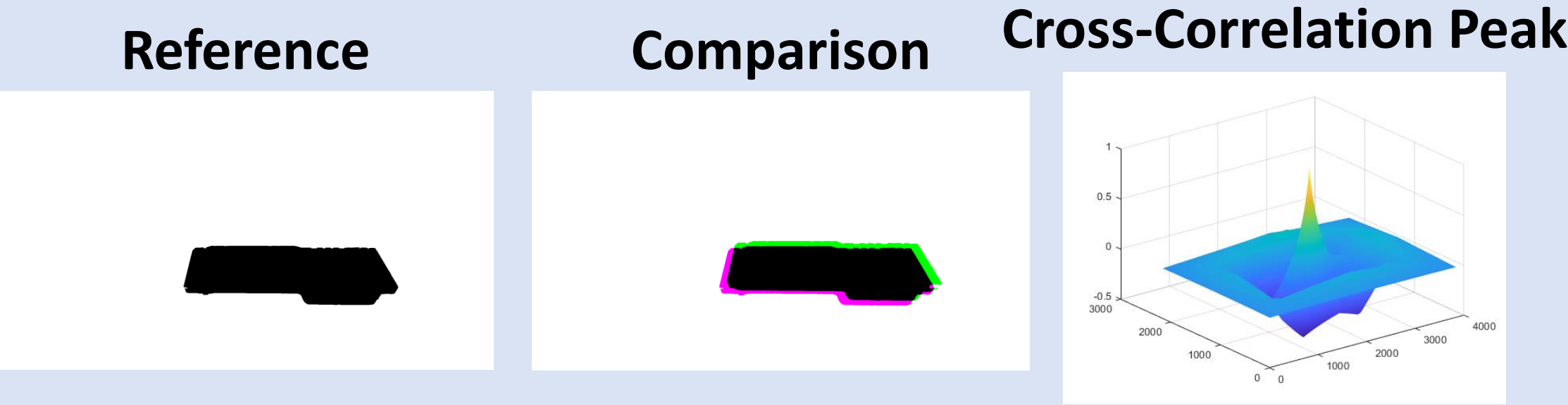
Isolation

- Color image thresholded into a binary image in each of the RGB layers, and summed together
- Extraneous noise removed



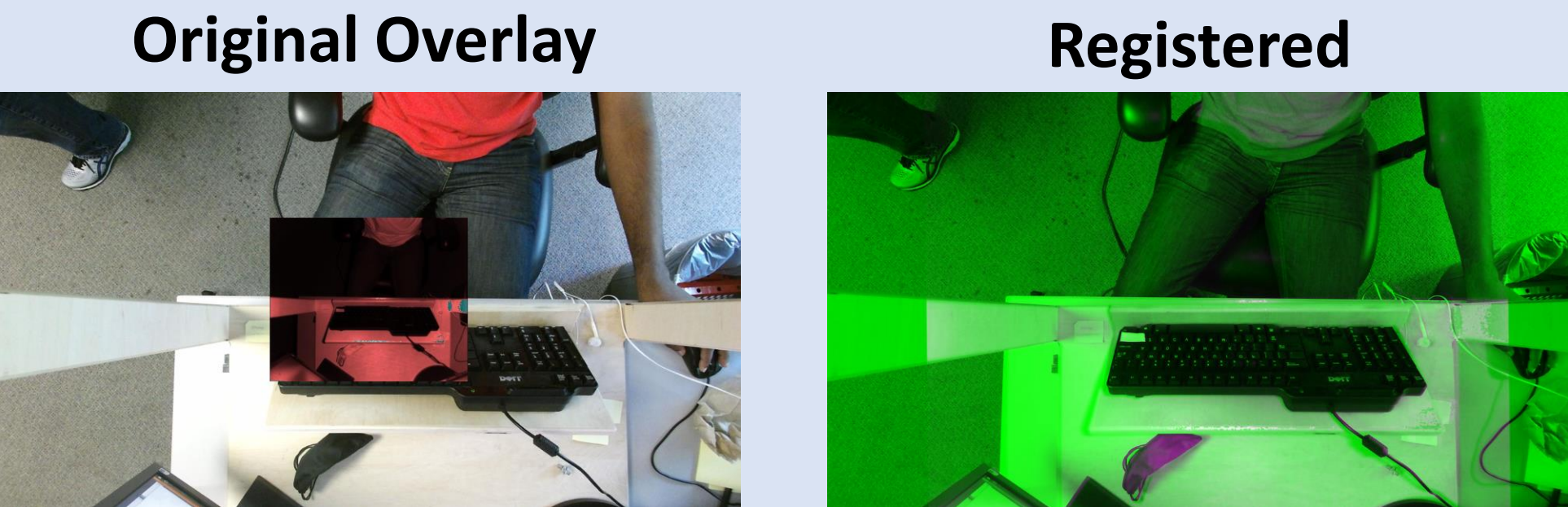
Calibration

- Keyboard silhouette obtained from the color image set as a reference image
- Key positions pre-defined on the keyboard silhouette for cross-correlation



Registration

- Information gathered from the isolated and calibrated color image mapped to the infrared image
- Finger movement in relation to the position of the keys and the keyboard detected with infrared sensor
- Differences in image resolution (color: 1080 x 1920 pixels; infrared: 424 x 512 pixels) and discrepancies in sensor location produce variations in images



Accomplishments & Future Work

- Current implementation of the system performs well
- Tested by Captain A, who recently typed a complete sentence for the first time using the system
- Integration of the MATLAB automatic calibration algorithm into the C# language of the main program
- Addition of a stabilization algorithm to improve the accuracy of finger detection and movement

Comments

The views expressed in this presentation are those of the author and do not reflect the official policy of the Department of Army/Navy/Air Force, Department of Defense, or U.S. Government.